

CLAIMS

1. A liquid crystal display device having a liquid crystal panel including a first substrate, a second substrate, and a liquid crystal layer disposed between the first substrate and second substrate, and a light guide plate disposed on the side of the second substrate that is not in contact with the liquid crystal layer, said liquid crystal display device comprising:

a connection terminal part disposed to an edge portion of the second substrate on the side thereof in contact with the liquid crystal layer;

an excitation source disposed to an edge portion of the second substrate on the side thereof not in contact with the liquid crystal layer at a position opposite the connection terminal part; and

a light source disposed near at least one side of the light guide plate other than the side of the light guide plate closest to the excitation source so that light enters the light guide plate from the side to which the light source is disposed;

wherein the excitation source produces sound by causing the second substrate to flexurally vibrate according to an externally supplied sound signal.

2. A liquid crystal display device as described in claim 1, wherein the light source is disposed opposite the excitation source with the light guide plate therebetween.

3. A liquid crystal display device as described in claim 1, wherein the light source is disposed near a side of the light guide plate that is adjacent to the side closest to the excitation source.

4. A liquid crystal display device having a liquid crystal panel including a first substrate, a second substrate, and a liquid crystal layer disposed between the first substrate and

second substrate, and a light guide plate disposed on the side of the first substrate or second substrate that is not in contact with the liquid crystal layer, said liquid crystal display device comprising:

5 a light source disposed near a predetermined side of the light guide plate so that light enters the light guide plate from said predetermined side; and

10 an excitation source disposed to an edge portion of the first or second substrate near a side of the light guide plate other than said predetermined side;

 wherein the excitation source produces sound by causing the first or second substrate to flexurally vibrate according to an externally supplied sound signal.

15 5. A liquid crystal display device as described in claim 4, wherein the light source is disposed opposite the excitation source with the light guide plate therebetween.

20 6. A liquid crystal display device as described in claim 4, wherein the light source is disposed near a side of the light guide plate that is adjacent to the side closest to the excitation source.

25 7. A liquid crystal display device as described in any of claims 1 to 6, further comprising:

 a frame for housing the liquid crystal panel and light guide plate;

30 wherein the excitation source is disposed in contact with the frame or bonded to the frame, and causes the frame to flexurally vibrate according to the sound signal.

8. A liquid crystal display device as described in any of claims 1 to 6, wherein:

35 the first and second substrates comprise a glass plate of which one side is in contact with the liquid crystal layer, and

a sheet of optical material disposed to cover a predetermined effective display area on the other side of the glass plate; and

5 the excitation source is disposed in contact with the glass plate at an edge portion thereof in an area outside the effective display area on said other side of the first or second substrate, and directly causes the glass plate to flexurally vibrate according to said sound signal.

10 9. A liquid crystal display device as described in any of claims 1 to 3, wherein the excitation source is disposed to an edge portion of the second substrate on the side thereof not in contact with the liquid crystal layer at a position corresponding to a middle portion of the connection terminal
15 part.

10. A liquid crystal display device as described in claim 9, further comprising:

a frame for housing the liquid crystal panel and light
20 guide plate; and

a chassis fit to an inside surface on the back side of the frame for supporting the liquid crystal panel;

wherein the liquid crystal panel is housed in the frame so that the first substrate is positioned on the front side and
25 the second substrate is positioned on the back side; and

the chassis has a thick-walled portion formed in corner areas at both end parts of the edge portion on the side of the second substrate not in contact with the liquid crystal layer.

30 11. A liquid crystal display device as described in any of claims 1 to 6, further comprising:

at least one other excitation source in addition to said excitation source;

wherein said other excitation source causes the first or
35 second substrate to flexurally vibrate according to an externally supplied sound signal.

12. A liquid crystal display device as described in any of claims 1 to 6, further comprising:

5 a pickup unit for converting vibrations of the first or second substrate to electric signals when external sound waves cause the first or second substrate to vibrate;

wherein said pickup unit is disposed instead of the excitation source in the position of the excitation source, or is disposed near said excitation source together with said
10 excitation source.

13. An electronic device having a liquid crystal display device as described in claim 11, comprising:

15 a signal processing means for changing the sound output position in the first or second substrate by controlling the phase and amplitude of sound signals to be input to the plurality of excitation sources including said other excitation source.

20 14. An electronic device having a liquid crystal display device as described in claim 11, comprising:

a data processing means for receiving combined data containing image data representing an image to be displayed on the liquid crystal panel and position data denoting a sound
25 output position in the image, and separating and outputting the image data and position data; and

a signal processing means for controlling the phase and amplitude of sound signals to be input to the plurality of excitation sources including said other excitation source based
30 on the position data output from the data processing means so that sound is output from a position in the first or second substrate corresponding to the sound output position in the image.

35 15. An electronic device comprising a liquid crystal display device as described in any of claims 1 to 12.

16. A liquid crystal display device as described in any of claims 1 to 6, further comprising:

5 a frame for housing the liquid crystal panel and light guide plate; and

a structural panel disposed between the frame and the liquid crystal panel or the light guide plate so that one side of the structural panel is in contact with the inside surface of the frame;

10 wherein the excitation source is disposed in contact with the other side of the structural panel, or bonded to said other side, and causes the frame to flexurally vibrate according to the sound signal simultaneously to the liquid crystal panel by way of the intervening structural panel.

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17. A liquid crystal display device as described in claim 16, wherein the structural panel is located on the display surface side of the liquid crystal panel and comprises a sensor function for functioning as an operating unit.

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18. A liquid crystal display device as described in claim 16, wherein the structural panel is located on the display surface side of the liquid crystal panel and comprises a complementary display.

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19. A liquid crystal display device as described in claim 17 or 18, wherein the structural panel has a display indicating functions executed by predetermined operations; and

30 the excitation source receives a signal denoting a vibration pattern corresponding to the predetermined operation from a predetermined signal generating means disposed externally or internally to the liquid crystal display device, and causes the structural panel to flexurally vibrate in a vibration pattern corresponding to the predetermined operation
35 based on said signal.

20. An electronic device comprising a liquid crystal display device as described in any of claims 16 to 19.

21. A liquid crystal display device having a liquid crystal panel including a first substrate, a second substrate, and a liquid crystal layer disposed between the first substrate and second substrate, a light guide plate disposed on the side of the second substrate that is not in contact with the liquid crystal layer, and a frame for housing the liquid crystal panel and light guide plate, said liquid crystal display device comprising:

a connection terminal part disposed to an edge portion on the side of the second substrate in contact with the liquid crystal layer;

an excitation source disposed bonded to the inside surface of the frame at a position facing an edge portion of the second substrate on the surface thereof not in contact with the liquid crystal layer at a position on the opposite side as the connection terminal part so that vibration is not transmitted directly to said opposite-side edge portion; and

a light source held in the frame and disposed near at least one side of the light guide plate other than the side of the light guide plate closest to the excitation source so that light enters the light guide plate from the at least one side to which the light source is disposed;

wherein the excitation source produces sound by causing the frame to flexurally vibrate according to an externally supplied sound signal.

22. A liquid crystal display device as described in claim 21, wherein the excitation source is disposed with a space between the excitation source and the second substrate to avoid contact with the second substrate at the expected vibration amplitude of the excitation source.

23. A liquid crystal display device as described in claim 21, further comprising a buffer material between the excitation source and the second substrate.

5 24. A liquid crystal display device as described in any of claims 21 to 23, further comprising a buffer material between the liquid crystal panel and frame.

10 25. A liquid crystal display device as described in any of claims 21 to 24, further comprising a buffer material between the liquid crystal panel and light guide plate.

15 26. A liquid crystal display device as described in any of claims 21 to 24, further comprising a buffer material between the light guide plate and frame.

20 27. A liquid crystal display device as described in any of claims 21 to 26, wherein the light source is disposed opposite the excitation source with the light guide plate therebetween.

25 28. A liquid crystal display device as described in any of claims 21 to 26, wherein the light source is disposed near a side of the light guide plate that is adjacent to the side closest to the excitation source.

29. A liquid crystal display device as described in any of claims 21 to 28, wherein:

30 the first and second substrates comprise a glass plate of which one side is in contact with the liquid crystal layer, and a sheet of optical material disposed to cover a predetermined effective display area on the other side of the glass plate; and

35 the excitation source is disposed in contact with the frame at an edge portion on said other side of the first or second substrate in an area outside the effective display area,

and causes the frame to flexurally vibrate according to said sound signal.

30. A liquid crystal display device as described in any of
5 claims 21 to 29, wherein the excitation source is disposed to an edge portion of the second substrate on the side thereof not in contact with the liquid crystal layer at a position corresponding to a middle portion of the connection terminal part.

10 31. A liquid crystal display device as described in claim 30, further comprising:

a chassis fit to an inside surface on the back side of the frame for supporting the liquid crystal panel;

15 wherein the liquid crystal panel is housed in the frame so that the first substrate is positioned on the front side and the second substrate is positioned on the back side; and

the chassis has a thick-walled portion formed in corner areas at both end parts of the edge portion on the side of the
20 second substrate not in contact with the liquid crystal layer.

32. A liquid crystal display device as described in claim 31, further comprising a buffer material between the liquid crystal panel and the chassis.

25 33. A liquid crystal display device as described in claim 31, further comprising a buffer material between the chassis and the frame.

30 34. A liquid crystal display device as described in any of claims 21 to 33, further comprising:

at least one other excitation source in addition to said excitation source;

wherein said other excitation source causes the frame to
35 flexurally vibrate according to an externally supplied sound signal.

35. An electronic device comprising a liquid crystal display device as described in any of claims 21 to 34.